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Impact of $[\text{Al}_2\text{O}_3]/[\text{SiO}_2]$ on the Structure of Boroaluminosilicate Glasses

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Although boroaluminosilicate glasses are widely used in industry, their structure has not been well understood. To explore the structural details of these mixed network former systems, we have designed and synthesized ten $\text{Na}_2\text{O}-\text{B}_2\text{O}_3-\text{Al}_2\text{O}_3-\text{SiO}_2$ glasses with varying $[\text{Al}_2\text{O}_3]/[\text{SiO}_2]$ ratios. ^{11}B , ^{27}Al , ^{29}Si , and ^{23}Na magic angle spinning nuclear magnetic resonance (MAS NMR) experiments are performed to determine network speciation and modifier cation environment as a function of composition. Triple-quantum MAS NMR has also been used to provide additional structural insights. Raman spectroscopy is applied to obtain complementary information on the glass structure. Based on the structural characterizations, the different structural roles of Na_2O and the glass former mixing behavior are discussed. The fraction of each species is calculated, followed by a structural model that accounts for the NMR and Raman spectroscopy data.